

Future Demand for Ethanol and Adhesives Depend on Environmental Regulations

Producers are optimistic about ethanol's role in the 1990 Clean Air Act Amendments and are expanding their production capacities. The future of biodegradable polymers depends on government legislation and the development of a composting infrastructure. Given a stable 40-percent market share, natural adhesives and glues have great potential for environmentally friendly products. Roughly 2 to 3 percent of the total wheat crop will be used for industrial products in 1993/94, with 1- to 2-percent annual growth expected through 1996/97,

In the last issue of *Industrial Uses of Agricultural Materials Situation and Outlook Report* (June 1993), the combined demand for fuel-oxygenate additives (primarily corn-based fuel ethanol and natural gas-based methyl tertiary butyl ether [MTBE])--as a result of the 1990 Clean Air Act Amendments (CAM)--was estimated at 3.7 billion gallons of ethanol equivalent by 1995/96, or more than three times current ethanol production. Assuming that corn-based ethanol captures 35 percent of the oxygenated fuels market, the demand for ethanol would reach 1.3 billion gallons. This would require an additional 123 million bushels of corn for fuel-ethanol production, thus raising the total use of corn for fuel ethanol to approximately 568 million bushels by 1995/96. These estimates depend heavily on ethanol's role in the ozone prevention provisions of the CAAA.

The carbon monoxide (CO) provisions of the CAAA were implemented last winter and the resulting demand for oxygenates was much lower than expected. Estimates of MTBE use range between 1.02 and 1.14 billion gallons, far lower than the 1.40 billion-gallon minimum some industry sources had expected. There were various reasons for the lower-than-expected demand. First, some cities that were expected to participate in the program did not--for example, Boston, MA; Duluth, MN; Memphis and Nashville, TN. Second, most analysts believed that refiners would supply towns and areas surrounding non-attainment cities with fuels to meet the CO provisions. Instead, refiners provided the outlying areas with cheaper grades that did not meet the provisions. Third, the number of towns surrounding non-attainment cities that voluntarily opted to join the program was much smaller than anticipated. Nevertheless, while total use fell short of expectations, oxygenate demand did increase dramatically due to the program.

The second stage of the CAAA is to be implemented in 1995. It requires reformulated gasoline in the nine worst ground-level ozone areas. Because splash-blended ethanol may increase evaporative emissions of volatile organic compounds (VOC's) and ethers like MTBE and ETBE (ethyl tertiary butyl ether) do not, ethanol blends will require lower volatility from the gasoline component than ether-gasoline mixtures. Depending on the cost of de-

creasing the volatility of gasoline, this could drive up the relative price of ethanol blends, and make it more difficult for ethanol to compete in the ozone non-attainment market. The Environmental Protection Agency (EPA) was scheduled to decide on December 15, 1993, whether to grant ethanol mixtures a waiver from the C A M volatility requirements. At press time, the ruling had not been announced.

Fuel Ethanol Capacity Increases

Even with the possible problems facing biobased fuel ethanol in ozone non-attainment markets, ethanol producers are optimistic about its future. A number of producers are raising their ethanol capacities. On July 24, Cargill broke ground for a \$200 million wet-milling corn plant in Blair, NE, that will go on line in 1995. The plant will produce a variety of corn products, including ethanol. The company already has an ethanol facility and will have a capacity of over 100 million gallons when both sites are operational. Also, last January, Midwest Grain Products announced a \$40 million expansion in their Pekin, IL, facility that will increase their ethanol capacity to over 90 million gallons per year by 1997.

Currently, over 32 companies produce ethanol through fermentation, with an annual capacity of over 1.37 billion gallons. Archer Daniels-Midland is the nation's largest ethanol producer with a capacity of 700 million gallons. Pekin Energy, the second largest fermentation producer, has a capacity of 100 million gallons. Other large fermentation producers include New Energy, 70 million gallons; Minnesota Corn Processors, 67 million gallons; South Point, 65 million gallons; A.E. Staley, 50 million gallons; and Midwest Grain Processing, 36 million gallons.

Biodegradable Polymer Use Depends on Legislation, Improved Technology, and Composting Infrastructure

In 1992, biodegradable polymer resins captured less than 5 million pounds of the plastics resin market. Provided that Congress does not mandate increased biodegradable polymer use, market penetration into the 8-billion-pound nonfood packaging market will likely be quite slow. The most conservative estimate of biopolymer consumption 0

puts total demand at roughly 8.4 million pounds of resin in 1995/1996.

According to industry analysts, the rate of market penetration of biodegradable polymers will depend upon three factors: the speed at which Federal, State, and local governments enact legislation requiring the use of degradables; how quickly the technology is improved and upgraded; and how quickly the industry can develop an adequate infrastructure for the collection and subsequent composting of organic waste materials.

On the legislative front, EPA recently issued guidelines stating that six-pack container rings must disintegrate within 35 days of placement in a marine environment. Also, a Florida law mandates that materials labeled as biodegradable do so within 120 days in a landfill. However, most of the legislative response has been aimed at funding increased biodegradable polymer research and development. In 1991, Congress passed an initiative mandating exploration of starch-based technologies and potential applications in biodegradable packaging materials. (See the Introduction.)

With respect to composting, most manufacturers believe that a composting infrastructure is key to the success of biodegradable packaging. Dr. Narayan at Michigan Biotechnology Institute (MBI) argues that the foodservice industry is especially appealing for biodegradable polymers. The industry uses a great deal of plastic packaging daily. Because the plastics are contaminated by food waste, it would require a lot of time and effort to sort and clean the plastics to recycle them. In comparison, food wastes and biodegradable packaging could be collected together, placed in a composting facility, and disposed of in an ecologically friendly way.

Accordingly, MBI created a consortium, Compost Tech, which includes Cargill, Novon, Ecochem, the Minnesota Corn Growers Association, Philip Environmental, and Michigan State University. USDA is providing some basic research funding. The consortium will involve about 17 Burger King restaurants in Grand Rapids, MI, to demonstrate the logistics and economics of composting restaurant waste.

There are two parallel technologies being developed for biobased polymers--one uses starches and the other sugars derived from starch. Currently, the starch-based polymers dominate the industry and are less expensive. Starches are converted to plastic-like materials using a hydraulic, pressurized, mechanical process. However, moisture sensitivity has been a major concern. In comparison, sugar-based polymers make use of a fermentation process to chemically change the sugar directly to a polymer like poly-hydroxybutyrate/valerate or indirectly to lactic acid, which can then be converted into the polymer polylactic acid (PLA). The advantages of sugar-based polymers

include high rigidity, long shelf life, and good moisture resistance.

Prices for most biodegradable resins range anywhere from \$2 to \$5 per pound. In comparison, petroleum-based alternatives cost between 30 and 50 cents per pound. By the most optimistic estimates, biobased polymers will be at least twice as expensive as their non-degradable counterparts in the foreseeable future. Therefore, in the short term, promoters and investors are counting on the environmental advantage of biodegradable polymers to help drive product demand.

Novon Products, a division of the pharmaceutical giant Warner-Lambert, was the leading U.S. producer of starch-based biopolymers, with the capacity to produce 100 million pounds per year. Novon closed its facility in November 1993 and is now using its equipment for other purposes.

Novon's closure could have an impact on the industry, but there are other manufacturers prepared to step into the market. For example, Archer Daniels-Midland has gone into full-scale production of PLA from corn fermentation and Cargill is planning an \$8 million, 10-million-pound-per-year PLA plant that will be operational in February 1994. Cargill will produce polylactic acid from corn and other agricultural products. Ecochem, a partnership between DuPont and ConAgra, is also investing in PLA technology. Ecochem currently operates a \$20 million lactic acid plant and is planning a \$160 million addition to be built by 1995. Ecochem produces PLA from whey, a byproduct of cheese manufacturing.

A number of other companies are also producing biobased polymers. Uni-Star Industries produces a starch-based polymer that is currently used for loose-fill packaging. And American Excelsior produces a starch-based packaging material called Eco-Foam. The leading European producers of biodegradable polymers are Zeneca Bio Products in England (formerly ICI) and Novamont in Italy.

Environmental Concerns Drive the Adhesives Market

As stated in the June 1993 issue of this report, natural adhesives account for over 40 percent, or roughly 2 million tons annually, of total U.S. adhesives demand. Furthermore, the demand for natural adhesives was projected to exceed 2.2 million tons by 1995/1996. This translates to an additional 600 million pounds of starch by 1995/1996.

The main difference between natural and synthetic adhesives is in their applications. Synthetic adhesives are tougher and generally more water resistant than natural adhesives. However, current environmental concerns over synthetic adhesive systems and accompanying legislation have spurred new technologies using plant-derived starch.

Many of these new systems are intended for the packaging market.

Continued governmental pressures to reduce VOC emissions in adhesives and sealants are driving manufacturers to use formulations containing 100-percent solids, water-borne materials, and other nonvolatile compounds. There is no current or anticipated Federal legislation to cause radical disruption in the market. However, regional and State regulatory agencies will add greater pressure on lowering VOC's in adhesive formulations in the coming years.

Currently, there are over 600 adhesive manufacturers in the United States, producing a variety of both natural and synthetic adhesives and sealants with an estimated market value of over \$2 billion annually. H.B. Fuller Company is the leading producer of synthetic adhesives in the United States, while National Starch and Chemical Corporation is the leading producer of natural adhesives. Given a stable 40-percent market share, natural adhesives and glues show great potential for environmentally friendly products.

Industrial Uses of Wheat Starch

Although cornstarch dominates the industrial starch market, wheat starch is also used in manufacturing industrial products, albeit at a much lower level. While most of the 2.5-billion-bushel domestic wheat crop produced in 1993 will be used for food, feed, and seed; the Institute for Local Self-Reliance (ILSR)--a Washington, DC, based non-profit organization--estimates that 50 to 75 million bushels, or roughly 2 to 3 percent of the total crop, will be used for industrial products. ILSR expects a growth rate for existing industrial uses of 1 to 2 percent annually through 1996.

Also according to ILSR, approximately 3 percent of all fermentation ethanol made in the United States comes from wheat, using about 12 million bushels of wheat each year. Since the late 1980's, industry has been using wheat starch to produce several special grades of biodegradable polymeric resins for plastic applications. Wheat starch is also used in adhesives, building insulations, fertilizers, pesticides, cosmetics, pulp and paper products, pharmaceuticals, and drugs. Other industrial opportunities include body powders, nasal sprays, aerogel insulation in refrigerators and greenhouses, and dish-washing detergents.

Examples of wheat-based industrial producers are:

- Xylan, Inc. (Madison, WI) produces a wide spectrum of products from wheat components, including dietary fiber from wheat hulls, vital wheat gluten for the paper industry, and ethanol from the wheat kernel;
- Croda (Pasippany, NJ) has recently introduced wheat-based skin care and cosmetic products;
- Nature's Answer (Hauppauge, NY) supplies a line of wheat germ and avocado skin-care products. Specific products include wheat-germ body lotion and wheat-germ face cream; and
- Midwest Grain Products produces fuel ethanol from wheat and is currently in the process of increasing their fermentation ethanol capacity to over 90 million gallons per year by 1997. The company is also expanding its wheat gluten production facility. Wheat gluten is a high-protein ingredient used extensively in bakery products, pet foods, cereals, and has shown promise for nonfood consumer end-products. Douglas Beach (202) 219-0085 and Irshad Ahmed (202) 232-4108]